

Project Lion



Government of Rajasthan
FOREST DEPARTMENT



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

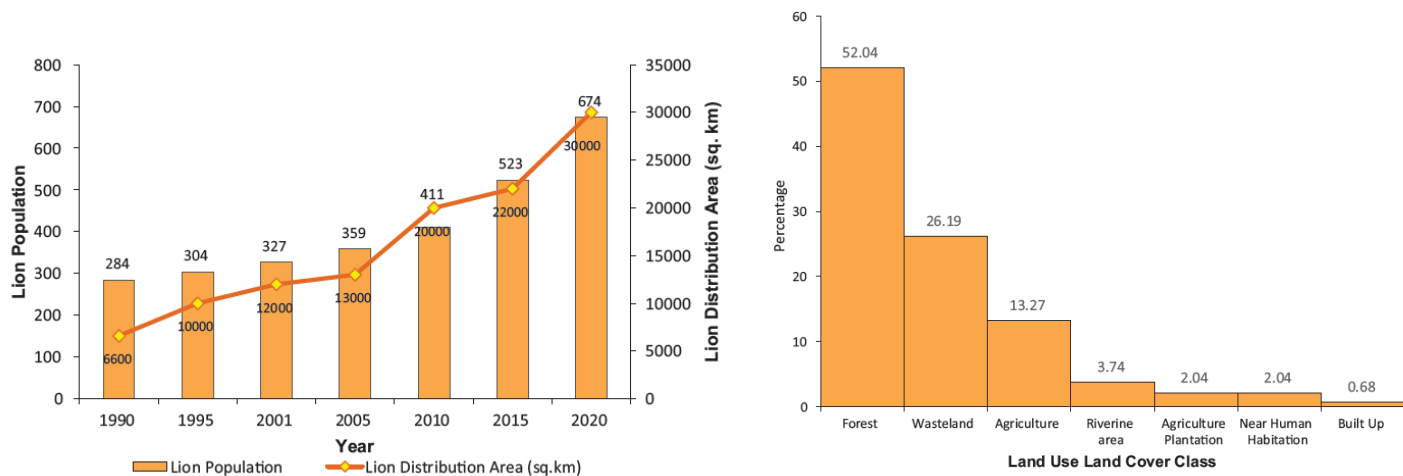
Project Lion

Project Proposal Developed by the Wildlife Institute of India in Consultation with Gujarat Forest Department

Introduction

India is the last home of the Asiatic lion (*Panthera leo persica*). After the initial efforts of the erstwhile rulers of Junagadh prior to India's independence the last 50 odd wild lions were saved from trophy hunting in the Gir Forests of Saurashtra. Lions were initially made the National animal of India after independence, the status which they subsequently lost to the tiger in 1973. Subsequently with the efforts of the government of Gujarat State and the Gujarat Forest Department, lions have since increased to around 674 occupying cumulatively about ~30,000 km² of human dominated landscape in Kathiawar peninsula (with sightings and kill recorded in areas spanning 9 districts over the years) (Figure 1). Honorable Prime Minister Shri Narendra Modi led celebrations when it was announced in June 2020 that Asiatic lion population in Gujarat had grown by almost 29% over the last five years. The Prime Minister himself shared this news with the nation and tweeted, "Over the last several years, the Lion population in Gujarat has been steadily rising. This is powered by community participation, emphasis on technology, wildlife healthcare, proper habitat management and steps to minimize human-lion conflict. Hope this positive trend continues!"

Figure 1: Growth of Asiatic lion populations during past 30 years & different land use land cover classes of Saurashtra landscape being currently used by lions (Source: Gujarat Forest Department)



The conservation of the Asiatic lion in the greater Gir ecosystem is a conservation success story and largely the credit can be attributed to the people of Saurashtra who have a special cultural bond and extreme tolerance toward this large carnivore. However, with an increase in lion abundance and density and spread of lion occupied areas in the landscape, unique problems that were hitherto not experienced by conservation practitioners have emerged. A fresh approach that imbibes a thorough understanding of lion ecology, socio-economics of the local communities, and the development agenda of the region is required to ensure the continued persistence of the Asiatic lions in India.

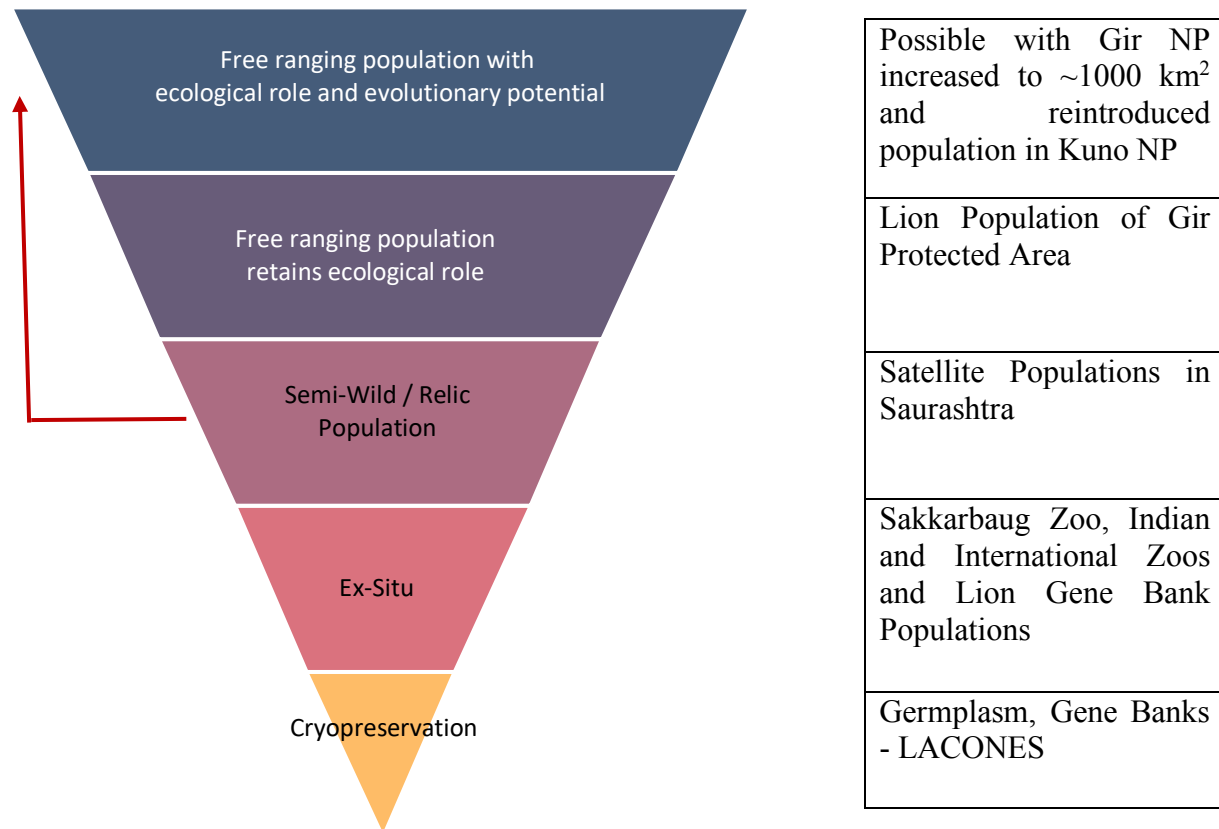
Need and Rationale: Best Interest of the Species

Honorable Prime Minister, recognizing the best interest of Asiatic lions shared the Government's resolve and commitment to work for the long-term conservation from the ramparts of Red Fort in his speech on 74th Independence Day. The Prime Minister announced Project Lion for securing the future of Asiatic lions in the country.

The evolving scenario calls for even greater involvement of local communities in a range of activities including habitat augmentation and improvement, lion monitoring, shared usage of resources, man-animal conflict mitigation etc. for keeping this growing population healthy. The lions are now reaching in new areas where human settlements are predominant and the communities there, unlike peripheral areas of Gir forest, have not lived with lions in memorable past. In such a context, participatory management of the growing lion populations becomes imperative. Gujarat Forest Department has been seeking community participation in a big way in an attempt to reinforce a favorable perception towards lions and wildlife in general in minds of people in entire landscape. This is the primary aspect which is to be strengthened under the Lion Project over a period of time.

The ultimate goal of all species conservation projects including that of Project Lion should be to ensure that "Lions perform their ecological role in the ecosystem and retain their evolutionary potential". The ecological role of the Asiatic lion has been as an apex predator. Though this ultimate goal is what we should strive to achieve, it is often difficult to achieve in all scenarios and conservation goals have to be compromised to lower standards (Figure 2). All these lower conservation goals coalesce to prevent extinction of a species and are important cumulatively. The Gir Protected Area (PA) population and a reintroduced population in Kuno National Park (Madhya Pradesh) has the potential to achieve the ultimate goal, provided sufficient inviolate space is made available for lions in their protected habitat.

Figure 2: Conservation objectives as an inverted pyramid signifying their relative importance. The ultimate conservation goal is to establish free ranging populations of lions that perform their ecological role as well as retain their evolutionary potential.



For the first time, the entire genome of Asiatic lion has been sequenced by scientists from CSIR-Centre for Cellular and Molecular Biology, Hyderabad. The full genome sequencing of Gir lions has shown them to be lacking genetic diversity in comparison to other lion populations and historical samples of Asiatic lions ¹⁻⁴. The objectives of these studies are to understand the species at DNA level and study if there are any specific problems with regard to adaptability to environment or behavior vis-à-vis other big cats. It is a well-known principle of conservation biology that genetic diversity enhances adaptability to changing environmental (biotic and abiotic) conditions ⁵. However, even genetically depauperate species can survive for the long-term (e.g. the cheetah ⁶ and the Gir lions). An essential element for the survival of inbred species is the mechanism of purging deleterious genes through natural selection ^{7,8}. It was suggested by several researchers time and again that the Asiatic lion may have low genetic diversity index and it is a concern in the long-term conservation of Gir lions ⁹. Genetic studies and demographic management of populations may be guiding principle for further conservation of the Asiatic lion.

Further, in recent times, with increasing population, changing population dynamics and expansion of the territory, the overall health scenario of this population is also a cause of concern and science driven health management is needed. Susceptibility to diseases and chance of an epidemic type of outbreak is to be addressed through this project. This can and needs to be combated through demographic and genetic management of the lion population as a meta-population. Along with existing satellite populations, other free ranging populations need to be established. The gene exchange to enrich the existing genetic diversity among these population is to be taken up. The genepool program may offer solutions to infuse variations. Several populations will also act as a safety net against catastrophic events like epidemics or natural calamities that can wipe out single populations. Current lion population in Saurashtra is one big gene pool, with individuals exchanged between the Gir PA and satellite populations on a regular basis as shown by satellite-GPS-telemetry study ¹⁰. The lion population of the Gir PA being the source population and the satellite populations being sinks. Immigration is an essential element for the survival of these satellite populations ¹¹ (see Appendix 1 for Population Viability Analysis - PVA). With infrastructure, urban sprawl and industrialization on the increase, it is important to identify lion dispersal routes and ensure green norms for development projects traversing these corridors so as to safeguard the future of the satellite populations which cannot exist without immigrants. For satellite population viability immigration is an essential demographic process, but this makes the entire landscape susceptible to epidemics like Canine Distemper and Rabies. Since the intervening human dominated habitat matrix between lion satellite population teems with domestic and feral animal vectors for these diseases, the Saurashtra lion population would be vulnerable to epidemics that can cause catastrophic mortality and put the entire single Asiatic lion population at risk of extinction. This threat was recognized by the Gujarat Government through a PHVA analysis done under the leadership of the eminent conservation scientist Dr. Ulysses Seal, senior Forest Officials of Gujarat and wildlife biologists at Baroda in 1993 ¹². The Hon'ble Apex Court of India passed a land-mark judgement in 2013 mandating the Ministry of Environment Forests and Climate Change, GoI, Government of Gujarat and Government of Madhya Pradesh to work together and establish a reintroduced lion population in Kuno Wildlife Sanctuary, Madhya Pradesh. Progress towards this has been made on the principles laid down by the IUCN guidelines (2013) for reintroductions and the third draft action plan prepared by the expert panel appointed by the Hon'ble Supreme Court is under consideration by the three governments.

Goal of the Project Lion:

Asiatic Lions Should Play Their Ecological Role and Retain Their Evolutionary Potential. The Future Generation of Indians should be Proud of Their Natural Heritage which will be Preserved as Nature intended it to be.

Objectives

1. To manage growing lion populations in Gujarat.

2. To ensure that local communities, people of Saurashtra and of India are the main stakeholders and benefitted by Project Lion and Lion conservation
3. To secure and manage lion habitat and mitigate human-lion conflict
4. To avert any risk of extinction to Asiatic lions and ensure their perpetuation for generations to come

Proposed Activities

Habitat and Population

- 1) Create inviolate space for lions within Gir PA. Large carnivores need vast areas for viable populations and for this reason they serve as umbrella species for biodiversity with the Protected Area designed for their conservation. For Tiger Conservation the mandate of National Tiger Conservation Authority is to have an inviolate space of 800-1000 km² as core area for a tiger reserve and with a buffer of another 800-1000 km². It is within this human free core where tigers perform their ecological role. Currently, the only exclusive space for lions is the 250 km² of the Gir National Park. The rest of the range of the Asiatic lion is shared with people and the lion population subsists of human subsidies. It is important that Project Lion restores sufficient exclusive lion habitat of about 1000 km² through incentivized voluntary relocation of forest villages and Maldhari (local pastoral communities) settlements from within Gir Conservation Areas so that the only surviving Asiatic lion population gets the space it requires for performing its ecological role. The Maldharis living within Gir PA make a 75% higher profit compared to Maldharis living outside the PA due to free access to grazing, sale of manure with topsoil, and compensation for predated livestock ¹³. Therefore, an appropriately lucrative rehabilitation package for incentivized relocation would need to be worked out and offered to all forest dwellers within the core zone to relocate outside with hand holding and additional perks which may be available from the Gujarat State Government.

Time frame: 5-10 years; Responsibilities: Gujarat Forest Department, Madhya Pradesh Forest Department and Rajasthan Forest Department

- 2) Habitat improvement and augmentation is crucial to manage the growing population in a variety of land use and land cover categories. Besides managing and augmenting the habitat in the protected areas as per management plan, restoration of grasslands (reserved and non-reserved), development of peripheral forests as ideal habitat, securing shelter belts and refuge patches, lion corridor development and incentive driven lion friendly management in eco-sensitive zone is the key to maintain the thriving population of Asiatic lions. This should be the focus of the Lion project in times to come. Due to overgrazing by livestock many of these habitats are degraded and infested with invasive weeds and shrubs like *Lantana camara*, *Cenchrus ciliaris*, and *Prosopis juliflora* ^{14,15}. The habitat improvement and augmentation efforts in areas other than protected areas must be dovetailed with direct and indirect benefits to the local communities by mechanisms such as sharing of proceeds, grass etc. Project Lion will address these management activities.

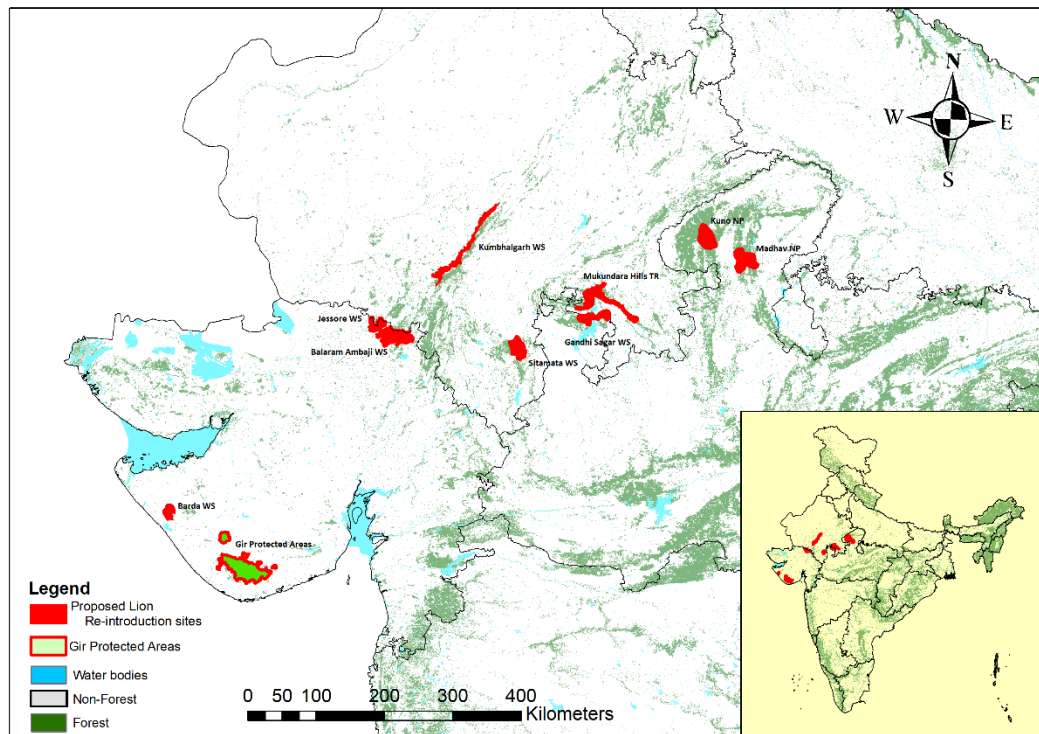
Time frame: On a continuous basis. Responsibilities: Gujarat Forest Department, Madhya Pradesh Forest Department and Rajasthan Forest Department

- 3) Create additional safety net free ranging populations within Gujarat and in India. The Barda Wildlife Sanctuary has been identified and assessed by the Wildlife Institute of India as a potential site where a population of 40 lions can be accommodated in the larger landscape of Barda-Alech hills and coastal forests ¹⁶. Investments for incentivized voluntary

relocation of Maldhari families from within Barda WLS needs to be done under Project Lion. The Barda Maldharis are willing to relocate and a good incentive will free the wildlife sanctuary for lion reintroduction¹⁶. The other such potential sites may be further explored and progress may be made as per IUCN guidelines (Figure 3; see Appendix 2 for other sites within Gujarat and in other States). As per the Hon'ble Apex Court's order good progress has been made for reintroduction of lions to Kuno National Park, with Madhya Pradesh declaring the entire Kuno WLS and Wildlife Division as a National Park (750 km²) devoid of humans which is larger than the current Gir National Park (250 km²) (see Appendix 3 for a comparison between Gir and Kuno).

Time frame: 5-10 years; Responsibility: Gujarat Forest Department, Madhya Pradesh Forest Department, Ministry of Environment Forest and Climate Change GOI, and Wildlife Institute of India.

Figure 3: Potential sites in Gujarat and elsewhere in India for establishing alternative populations of Asiatic lions



- 4) After establishing such lion populations these populations would be managed as a meta-population after disease and genetic studies of individuals to manage the demography in light of the lower genetic diversity in this subspecies of lions. With the current understanding based on full genome sequencing of all representative lions from across their range as well as historical samples ^{3,4}, the Gir lions along with Central and West African lions have been renamed as *Panthera leo leo*, while the east and southern African lions have been named as *Panthera leo melonochaita* ¹⁷. The Asiatic lions have close genetic affinity with extant West African and Central African lions. However, these west and central African lion populations are under severe threat of extinction and the Gir lions can potentially play a significant role in rescuing these lion populations in the future. Genetic rescue has been successfully done in the Florida Puma (*Puma concolor coryi*, ¹⁸) and is likely to be necessary for some lion populations across their range in Africa and India ¹⁹.

Time frame: On a continuous basis. Responsibility: Gujarat Forest Department, Madhya Pradesh Forest Department, Ministry of Environment Forest and Climate Change GOI, and Wildlife Institute of India.

- 5) Traditional total count method is currently used to estimate status of Asiatic lions every five years by the Gujarat State Forest Department. Total counts are rarely possible in a free ranging population since not all animals are detected and often it is not possible to avoid double counts of the same individuals. These shortfalls of total counts are explicitly addressed by WII with a robust scientific approach to estimate abundance through individual animal identification ^{20,21} and technique such as spatially explicit capture recapture (SECR) ²². The National Tiger Status evaluation carried out by the National Tiger Conservation Authority (NTCA)-WII in collaboration with State Forest Departments is a holistic assessment of prey, other carnivores, habitat and anthropogenic impacts along with tiger population estimation ²³. This exercise provides information that is useful for policy and management. Similar strategy should be adopted for evaluating the Status of Lions in Saurashtra Landscape at present and other landscapes in future.

Time frame: On a continuous basis at an interval of every 4 years. Responsibility: Gujarat Forest Department, Madhya Pradesh Forest Department, Rajasthan Forest Department and Wildlife Institute of India.

Community participation

- 1) Community participation and making them the stake holders is vital. The communities have a sense of pride and responsibility. This overarching sense needs to be converted into an information-sharing and monitoring mechanism. Public outreach is the key. Under its Vanyaprani Mitra (friends of wildlife) scheme, Gujarat Forest Department engages local youths who share intelligence about movement of wildlife and also act as a bridge between forest department and local communities. Currently, around 400 Vanyaprani Mitras are engaged and the Forest Department gives them honorarium. The scope of this scheme to more villages in lion landscapes of Gir and elsewhere may be expanded. Communities needs to be sensitized about the upcoming challenges of the growing lion population. The

Project Lion will engage village Panchayats and encourage farmers to manage their land in a lion friendly manner to promote more space for wildlife in a rapidly developing landscape.

Time frame: On a continuous basis. Responsibility: State Forest Departments.

- 2) Supporting livelihoods is key element in winning community support. The proposed eco-tourism zones in the current Management Plan at Chikhalkuba and Girnar may be further developed so that local livelihoods from these regions can be benefitted. Similar eco-tourism as per prevailing guidelines and policy may also take up in newer areas.

Time frame: On a continuous basis. Responsibility: Gujarat Forest Department.

Management of Disease and Epidemics

- 1) Overall health and well-being of this endangered sub-species is crucial. Recent incidences of CDV and Babesiosis-related deaths of lions underline the gravity and urgency. Keeping in mind the natural processes of purging deleterious alleles, disease ecology and epidemiology; healthcare of lions will be very selective as per the advice provided by the best global experts from veterinary, genetics, and ecological fields to avoid any detrimental impacts on free ranging wild populations. A standard operating procedure (SOP) in the line of NTCA SOP on dealing with orphaned/abandoned tiger cubs and treating old/sick/injured individuals may also be developed for lions under Project Lion. The existing infrastructure and logistics need to be strengthened.

Time frame: On a continuous basis. Responsibility: Gujarat Forest Department, Ministry of Environment Forest and Climate Change GOI, Wildlife Institute of India, Indian Veterinary Research Institute (IVRI) and International Experts.

- 2) Disease Profile and Ecology in the Greater Gir Landscape as well as in other reintroduction sites: Understanding the profile of all pathogens, their hosts and epidemiology in relation to wildlife and domestic livestock is essential for prophylactic management of potential epidemics. This study along with vaccination of domestic and feral animals will be undertaken within the Saurashtra landscape and other potential reintroduction sites. Further, disposal of cattle carcass must be streamlined with support from panchayats, panjrapols and gaushalas. Standard operating guidelines for the above aspects is the need of the day for containing the transfer of any pathogen/diseases from livestock or stray dogs to wild animals. This way of transfer of diseases and addition of pathogenic load in the wild needs to be checked. Interventions in the form of treatment to wildlife including lions will be kept to a minimum and only when required and advised by scientists.

Time frame: On a continuous basis. Responsibility: IVRI, WII in collaboration with state forest departments.

Human-Wildlife Conflict

- 1) Increase in number of lions also means increased human lion conflicts in addition to other human-wildlife conflicts (Figures 4 & 5). Besides effective compensation regime what is needed is extension of human-wildlife conflict mitigation measures. Especially with

regards to farmers, the Forest Department has started providing machans (watch stations for crop protection) which is a very welcome scheme among farmer communities. This along with other mitigation solutions like pulsating temporary power fencing, insurance schemes for crop and livestock damage, needs to be explored and extended under Project Lion. Crop raiding by wild ungulates is another equally important cause of wild animal conflict with local communities. Effective mitigation measures must be explored suitable for safe repulsion from farmlands and implemented.

Time frame: 5 years and then on a continuous basis. Responsibility: Gujarat and other State Forest Departments

Figure 4: Intensity of livestock depredation by lions in the Saurashtra Landscape.

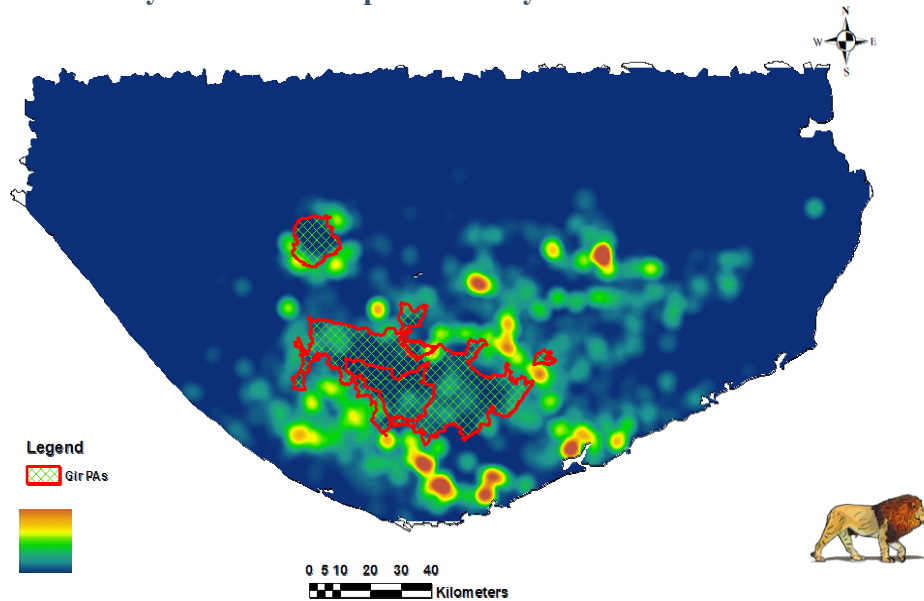
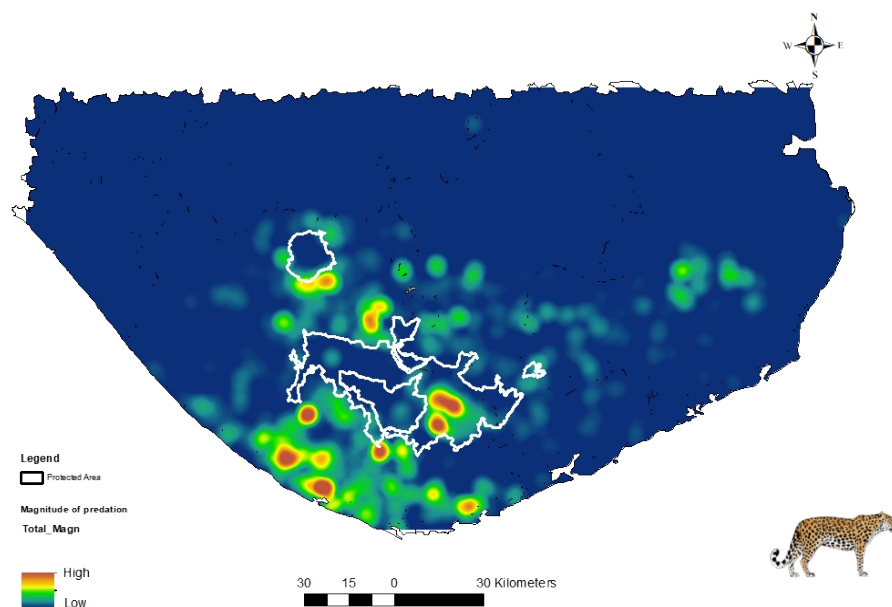


Figure 5: Intensity of leopard predation on livestock in Saurashtra Landscape.



- 2) Strengthening of quick response teams for mitigating conflict across current and setting up new teams in potential lion habitat. Four-wheel drive vehicles equipped with darting and capture equipment, wildlife capture trained veterinary officer and his team will be deployed at strategic locations to address human-wildlife (lion/leopard) conflict and rescue.

Time frame: 1 year for strengthening and then on a continuous basis. Responsibility: State Forest Departments

- 3) Reproductive control of certain wildlife species like leopards in pockets where they are over abundant may be required to reduce their population growth and density. More human lives are lost to leopard attacks than tigers and lions combined in India. Many ungulate species like nilgai and wild pigs have become locally abundant and are responsible for large economic losses to farmers creating hostility towards Protected Areas. Immuno-contraception and chemical contraception options that are humane ways to reduce fecundity of these animals will be promoted on an experimental research basis by Project Lion in human dominated landscapes.

Time frame: On a continuous basis. Responsibility: Wildlife Institute of India, and subsequently State Forest Departments

Surveillance and monitoring

- 1) The Gujarat Forest Department aims to keep in line with the latest and state of the art technology. The Gir Hi-Tech Monitoring Unit, Sasan-Gir is one such of the many initiatives. The Gir Hi-Tech Monitoring Unit, Sasan-Gir was started on June 11, 2019 to continuously monitor the movement of radio-collared Asiatic Lions and field staff in the Asiatic Lion Landscape. The Gir Hi-Tech Monitoring Unit monitors various managerial segments in the Asiatic Lion Landscape 24*7. A Forest Management Information System with an easy Graphical User Interface called e-GujForest has also been developed by the Gujarat Forest Department which helps in recording observations regarding wildlife protection and in mapping them for further use in devising management strategies. Virtual geo-fencing has also been established in probable conflict sensitive areas to monitor the movement of radio-collared Asiatic Lions in those areas. On ground patrols of staff and their live monitoring is also being done using technology. The existing software and hardware infrastructure is to be further strengthened and maintained. Implementation of MStrIPES, a program developed by WII in collaboration with NTCA for monitoring tiger reserves and landscapes of India, should be explored to other potential lion reintroduction sites. The program can be customized for particular sites by incorporating relevant points for lion conservation.

Time frame: On a continuous basis. Responsibility: WII & Gujarat Forest Department initially and then by other state forest departments

- 2) Unlike tigers, lions do not have explicit body markings for individual identification. However, each lion has a unique pattern of whisker spots^{20, 21} and the WII has already developed a software “Program Lion”²⁴ that allows detailed history of each individual lion to be stored, compared, analyzed and used for population estimation, understanding long-

term demographic parameters and for monitoring. A Lion database to store all relevant information related to population, movement, health etc. is a need of the day. The same will be developed under this Lion project.

Time frame: 2 years and then on continuous basis. Responsibility: WII & Gujarat Forest Department initially and then by other state forest departments

Research

Research into population genetics, population monitoring, human-wildlife conflict, disease dynamics and ecology of lions, co-predators, ungulates and socio-economies of local communities will be undertaken under the ambit of Project Lion. An understanding of ecological and social carrying capacity of the Saurashtra and other potential reintroduction sites will be obtained from this research for better management of lions and their ecosystem.

Time frame: On a continuous basis. Responsibility: WII, IVRI, Other scientific institutions and universities in collaboration with the state forest departments.

Information Education and Communication

Regular press releases and reports would be made during the execution of the project at field sites of the project and also at regional and national level. An information cell will be developed. The official's in-charge of interaction with the media would be clearly identified, so that information flow may happen without any ambiguity. Every effort would be taken to ensure that the media gets an opportunity to understand the project and its implementation with clarity. IEC material will also be developed for community sensitization and awareness.

Time frame: On a continuous basis. Responsibility: MoEFCC, Gujarat Forest Department and State FDs

Manpower

With an aim of providing technical assistance to MoEFCC to achieve the objectives of Project Lion at national scale, a Lion Cell in the line of NTCA Tiger Cell & MoEFCC Elephant Cell may be established based at MoEFCC, Delhi and WII, Dehradun. The Cell should be manned by scientists having expertise in wildlife biology, conservation ecology, GIS and veterinary science.

Time frame: On a continuous basis. Responsibility: MoEFCC & WII

Monitoring and Advisory Committee

Monitoring and stock taking is key to the project. A National Supervisory and Advisory Committee would be constituted chaired by Director General of Forests, members as CWLW's of Gujarat, Madhya Pradesh, and Rajasthan (added as required by potential reintroduction sites); Director WII, two lion biologist experts and one IVRI scientist, member secretary as Additional Director General (wildlife). A local monitoring committee is proposed for operationalizing state level management under the Chairmanship of Chief Wildlife Wardens of the respective States wherein Inspector General (Wildlife) MoEF&CC, Govt. of India, Representative of Wildlife Institute of India, Indian Veterinary Research Institute, National Institute of Virology, and local bodies such as those for Gujarat can be Gujarat Biotechnology Research Center, CCF-Wildlife Junagadh Circle, Deputy/Additional Secretary- Wildlife, Government of Gujarat will be the members. Other invited members may be taken aboard by the Chairman and committee. These committees will monitor and assess the deliverables under the Lion Project and will advise on related matters.

Budget Proposal: The budget estimates (in crores, Indian Rupees) are proposed for the next 10 years.

Budget for Gujarat Forest Department

Item	Activity	Unit	Rate	Amount (Rs. in Crore)											Remarks
				1st Year	2nd Year	3rd Year	4th Year	5th year	6th Year	7th Year	8th Year	9th Year	10th Year	Total	
Habitat and Population															
	A. Inviolate space for lions : relocation / resettlement of maldharis in existing PA (Gir and Barda)	2500 Families	20 Lakh per Family	100	100	100	100	100	-	-	-	-	-	500	Relocation process may spill over upto 10 years since process is time consuming
	B. Wildlife habitat rejuvenation / reclamation in relocated areas.	LS	LS	-	1	1	1	1	2.5	2.5	2.5	2.5	2.5	16.5	
	Habitat Improvement and augmentation (PA & outside PA) - Restoration of Grassland, Development of peripheral forests as ideal habitat, securing shelter belts & refuge patches	50000 Ha. 10000 Ha. Per year	Rs. 10000 Per Ha., 5000 Ha per year Maint. from Next Year	10	15	15	15	15	2.5	2.5	2.5	2.5	2.5	82.5	With maintenance works from 5th to 10th year

	Lion Corridor development, incentive driven lion friendly management in eco-sensitive zone (Development of Riverine / Non Riverine Corridor)	LS	LS	10	10	10	10	10	10	10	10	10	10	100	
	Vegetation manipulation (thinning / decongestion / pollarding etc.) in PA areas.	5000 Ha. 500 Ha. Per Year	Rs. 60000 per Ha.	3	3	3	3	3	3.25	3.25	3.50	3.50	3.50	32	
	Water augmentation in Lion habitat	LS	LS	2.5	2.5	2.5	2.5	2.5	3	3	3	3	3	27.5	
	Create additional safety net free ranging populations (Barda)	LS	LS	10	5	5	5	5	2.5	2.5	2.5	2.5	2.5	42.5	After relocation or establishment or dispersal of Lion to Barda PA
	Managing Meta-populations : other Sites (Study / preparatory works)	LS	LS	2	2	2	2	2	2	2	2	2	2	20	
	Infrastructure for field staff														
	Protection chowky/ Thana/ field staff quarters etc. & maintenance	LS	LS	10	10	10	10	10	5	5	5	5	5	75	

	Patrolling / protection infrastructure Maintenance & Development														
	Patrolling road maintenance / Development	LS	LS	10	10	10	10	10	10	10	10	10	10	100	
	Fire Control & related infrastructure	LS	LS	1	1	1	1	1	1.5	1.5	1.5	1.5	1.5	12.5	
Communities	Community Participation and making them stakeholders														
	Information sharing and monitoring mechanisms (Viz. Vanyaprani Mitra)	500 Persons	Rs. 2500 Per month Per person	1.5	1.65	1.82	2.00	2.20	2.42	2.66	2.92	3.22	3.54	23.91	With 10% increase in wages / stipend from 2nd year onwards
	Public outreach and sensitization programme	LS	LS	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	75	
	Engaging peoples to have lion friendly management of their land & securing / purchase private lands (Seed money)	LS	LS	75	50	30	30	30	30	30	30	30	30	365	
	local livelihoods through ecotourism and other allied activities	LS	LS	5	5	5	5	5	5	5	5	5	5	50	

	Entry point activities / Eco-development activities in new lion area	LS	LS	5	5	5	5	5	5	5	5	5	5	50	
Lion Health Management															
	A. Purchase of New Ambulance	10 Nos.	LS	5	-	-	-	-	-	-	-	-	-	5	
	B. Operation & Maintenance including old ones	LS	LS	-	1	1	1	1	1.5	1.5	1.5	1.5	1.5	11.5	
	strengthening of existing infrastructure and logistics & New treatment / transit facilities with maintenance	LS	LS	25	20	20	15	15	10	10	10	10	15	150	
Human Wildlife Conflict	Mitigation and adaptation measures														
	Manchan coverage in Lion / Leopard areas for farmers	35000 Manchan 3500 Beneficiaries per Year	Rs. 20000 Per Manchan	7	7	7	7	7	7	7	7	7	7	70	
	Protection / parapet wall for open well	15000 Nos. 1500 Well per year	Rs. 16000 Per well	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	24	
	Quick response teams	40 Teams													

	A. HR through outsourcing / Contract (Trekkers, Labour, Animal keeper, Worker)	160 Labours	Rs. 13500 Per person per month	2.6	2.86	3.15	3.46	3.81	4.19	4.61	5.07	5.57	6.13	41.44	With 10% increase in wages / stipend from 2nd year onwards
	B. Driver through outsourcing / Contract for response team / Ambulances	50 Persons	Rs. 13500 Per person per month	0.81	0.891	0.98	1.08	1.19	1.30	1.43	1.58	1.74	1.91	12.91	With 10% increase in wages / stipend from 2nd year onwards
	C. Veterinary Officers	10 Persons	Rs. 50000 Per Person Per month	0.6	0.66	0.73	0.80	0.88	0.97	1.06	1.17	1.29	1.41	9.56	With 10% increase in wages / stipend from 2nd year onwards
	D. Engaging Livestock Inspector	10 Persons	Rs. 18000 Per Person Per month	0.216	0.2376	0.26	0.29	0.32	0.35	0.38	0.42	0.46	0.51	3.44	With 10% increase in wages / stipend from 2nd year onwards
	Other related Misc. Activities	LS	LS	5	5	5	5	5	5	5	5	5	5	50	For contingency population estimation and other related miscellaneous activities
Surveillance and monitoring	Strengthening of existing software and hardware infrastructure & maintenance there after	LS	LS	5	2.5	2.5	2.5	2.5	1.5	1.5	1.5	1.5	1.5	22.5	
	Engaging IT Engineers	4 Persons	Rs. 35000 Per Person Per month	0.168	0.185	0.20	0.22	0.25	0.27	0.30	0.33	0.36	0.40	2.68	With 10% increase in wages / stipend from 2nd year onwards
	GIS specialist	3 Persons	Rs. 45000 Per	0.162	0.178	0.20	0.22	0.24	0.26	0.29	0.32	0.35	0.38	2.58	With 10% increase in

			Person Per month												wages / stipend from 2nd year onwards
	Data Operator	10 Persons	Rs. 13500 Per person per month	0.162	0.178	0.20	0.22	0.24	0.26	0.29	0.32	0.35	0.38	2.58	With 10% increase in wages / stipend from 2nd year onwards
	Rescue Vehicle (Purchase / Contract) & maintenance charges of vehicles including fuel.	LS	LS	2	2	2	2	2	2	2	2	2	2	20	
	Lion Database	LS	LS	2.5	0.5	0.5	0.5	0.5	1	1	1	1	1	9.5	
Research	Population genetics, population monitoring, lion ecology, disease dynamics	LS	LS	1	1	1	1	1	1	1	1	1	1	10	
	Strengthening of Leo Gene Lab	LS	LS	3	2	2	2	2	2	2	2	2	2	21	
	Engaging JRF/ SRF/ TA/ Research Assistant / Biologist	5 Persons	Rs. 35000 Per Person Per month	0.21	0.23	0.25	0.28	0.31	0.34	0.37	0.41	0.45	0.50	3.35	With 10% increase in wages / stipend from 2nd year onwards
Information, Education and Communication	Regular press releases, reports & IEC material and training	LS	LS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25	
	Information Cell	LS	LS	1	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5	0.5	4.5	
				318.83	280.22	260.93	256.71	257.56	136.50	137.54	138.93	140.18	146.56	2073.95	

Budget for National Level (outside of Saurashtra) Implementation of Project Lion

Component	Activity	Description	Amount (Rs. in Crore)											Agency to receive fund
			1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	Total	
Preparation of sites for lion reintroduction		Resettlement of human habitations to create inviolate space, habitat reclamation, grassland development, fencing, livestock vaccination, infrastructure and capacity building, awareness and community participation												
	Madhav NP		30	30	30	30	30						150	MPFD
	Sitamata WLS		36	36	36	36	36						180	RFD
	Mukundara Hills TR		65	65	65	65	65						325	RFD
	Gandhi Sagar WLS		30	30	30	30	30						150	MPFD
	Kumbhalgarh WLS		55	55	55	55	55						275	RFD
	Jessore Balaram Ambaji WLS		66	66	66	66	66						330	GFD
Lion reintroduction in Kuno NP		Lion capture (drug, capture & immobilization equipment), lion transport cost, lion soft release facility at release site, additional compensation	15	15	10	10	10	10	10	10	10	10	110	MPFD
Lion translocation cost for other sites		Lion capture (drug, capture & immobilization equipment), lion transport cost, lion soft release facility at release site				10	10	15	20	25	25	25	130	GFD, MPFD, RFD, WII

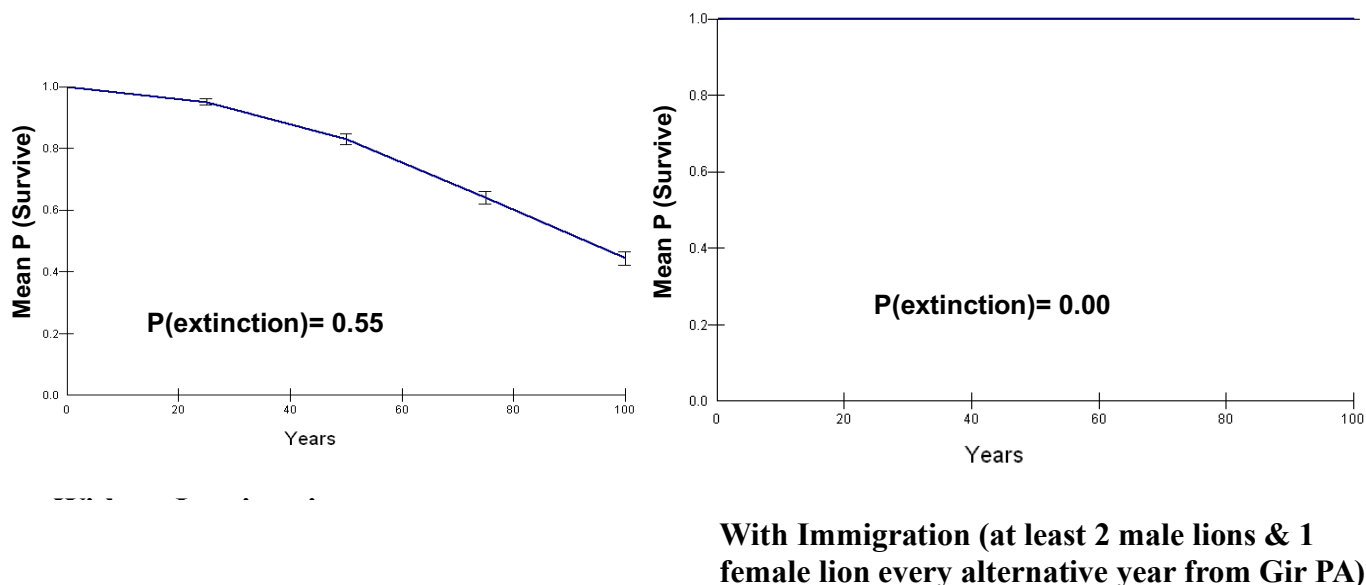
SECR based lion population estimation		A quadrennial exercise initially for Gujarat & thereafter for other sites	7			8				10			25	WII
Development & customization of Program LION and database for Gir, Kuno and other sites			1	1	1	2	2	2	2	3	3	3	20	WII
Implementation of MSTRIPES in Kuno & other sites		Customization of software, purchase of android phones, PC, laptops, server, training workshops	5	5	5	2	2	2	2	2	2	2	29	WII, State FDs
Development of tourism zone in Kuno & other sites		Master Plan, tourism infrastructures & Interpretation Centres	5	5	5	5	5	8	8	8	8	8	65	State FDs
Immunocontraception of leopards & other wildlife to mitigate conflict		Initially as a pilot project in Gujarat & subsequently in other states	5	5	5	5	5	8	8	8	8	8	65	WII, IVRI
Research														
	Saurashtra Landscape	Lion population genetics, population monitoring, human-wildlife conflict, disease dynamics and ecology of lions, co-predators, ungulates and socio-economies of local communities	2	2	2	2	2	2	2	2	2	2	20	WII

	Kuno	Ecological assessment & monitoring of Kuno Landscape as a potential site for lion reintroduction	2.5	2.5									5	WII
	Other potential sites	Ecological assessment of 6 sites for their potential for lion reintroduction	2	2	2								6	WII
Lion Cell at MoEFCC & WII		Salaries & other statutory benefits of 5-6 personnel, equipment, office expenses, operational cost, travel, Institutional liabilities etc. (with increase of salaries @ 10% per annum)	2.00	2.20	2.42	2.66	2.93	3.22	3.54	3.90	4.29	4.72	32	MoEFCC, WII
Information education and public outreach		For Kuno & other potential lion reintroduction sites	5	5	5	5	5	5	5	5	5	5	50	State FDs
Travel		International & domestic travel by MoEFCC, WII, IVRI, Lion Cell officials and international experts	1	1	1	1	1	1	1	1	1	1	10	MoEFCC, WII, State FDs
			334.5	327.7	320.4	334.7	326.9	56.2	61.5	77.9	68.3	68.7	1977	

Appendix 1: Population Viability Analysis

Currently the only free ranging population of about 674 Asiatic lions (*Panthera leo persica*) exists in the Gir landscape (approximately 30,000 km²) comprising of the Gir Protected Area (PA), Girnar Sanctuary, coastal scrublands and human dominated landscapes of Saurashtra peninsula, Gujarat²⁵. Lions are currently surviving in this landscape as a metapopulation wherein Gir PA acts as a ‘source’ and other satellite pockets act as ‘sinks’ and individual lions from different breeding populations can potentially disperse among these populations. A Population Viability Analysis (PVA) was performed for small, isolated Girnar lion population and the results suggest that the Girnar lion population could potentially survive for the short to medium term (25-50 years, probability of extinction 5-10%) without immigrants. However, for long term (100 years) persistence connectivity with the Gir PA is crucial¹¹. Even if 1-2 lions immigrate from Gir to Girnar Sanctuary once in two years, extinction probabilities are reduced by 45% (Figure 1). Thus Girnar population of lions exists as a metapopulation sink in connection with the Gir PA and the corridor habitat should be restored and managed as ‘eco-sensitive’.

Figure 1: Population Viability Analysis envisaging that for long term (100 years) persistence of Girnar lion population, habitat connectivity of Girnar Wildlife Sanctuary with the Gir Protected Area is crucial



About 2,500 years ago, the Kathiawar peninsula was separated from the mainland India by rising sea level causing the first genetic bottleneck that isolated the founders of the present Asiatic lion population compelling them to inbreed for several generations⁹. A second less severe bottleneck happened at the onset of the nineteenth century when lions became restricted to the Gir forests and their number declined to around 50 individuals due to hunting and habitat loss²⁶. Allozyme and microsatellite studies indicate that the Asiatic lion population is genetically monomorphic, attributed to an isolated inbred population with a small founder base^{9,27}. Decreased heterozygosity likely diminishes reproductive vigor and survival and is believed to impair a population's long-term viability^{28, 29}. Moreover, inbred carnivore populations restricted to single sites (such as Asiatic lions) face a variety of extinction threats from genetic and environmental stochastic factors³⁰. Catastrophes such as an epidemic, an unexpected decline in prey, natural calamities or retaliatory killings could result in the extinction of a threatened species when it is restricted to a single site. It is worth recording that an epidemic caused by a morbillivirus closely related to Canine Distemper Virus (CDV) emerged abruptly in the lion population of the Serengeti National Park, Tanzania in early 1994 resulting in fatal neurological disease characterized by grand mal seizures and myoclonus; the lions that died had encephalitis and pneumonia³¹. Recent outbreak of Babesiosis and CDV in Gir has already resulted into mortality of at least more than 60 lions during past two years. As the world is currently witnessing the rapid spread of corona virus during COVID outbreak, similarly, the CDV can also spread very fast within the entire lion population of Gir especially when containment is not possible due to feral animal vectors in a landscape that remains connected for disease transmission. This necessitates urgency for establishing geographically distant and distinct populations of a minimum size and subsequently managed them as a metapopulation with Gir. *In-situ* lion conservation would benefit from as many such free ranging populations as possible.

One such potential site identified by the Wildlife Institute of India was Kuno Wildlife Sanctuary in Madhya Pradesh³². A population habitat viability workshop for the Asiatic lions held at Baroda in October 1993 also reiterated the need of a second home for the species in Kuno along with other sites such as Sitamata, Darrah-Jawahar Sagar and Kumbhalgarh in Rajasthan and Barda in Gujarat¹². A PVA model was parameterized for Kuno by WII based on lion demographic data obtained from the Gir lion population³³. With conservative and realistic lion population parameters, the PVA incorporating environmental, genetic and demographic stochasticity, suggests that the lions reintroduced in Kuno will have high probabilities of long-term population persistence. The salient features that permitted population persistence were a i) carrying capacity of over 45 lions, ii) introducing an initial population of a minimum of twelve individuals (5-7 breeding females and 2-3 breeding males) and iii) supplementation with a minimum of six individuals (two males and four females) every four year for the next 16 - 20 years. Even with this strategy long-term (> 200 years) lion persistence in Kuno requires a population of over 80 lions. This can be achieved by increasing the size of the Protected Area combined with an increase in prey abundance which will enhance the carrying capacity for the lions to the required level (20 – 25 years). The PVA models were extremely sensitive to loss of lions to human causes and therefore strict monitoring and protection

are required during the initial years of lion reintroduction in Kuno till the population size exceeds 60 lions.

Appendix 2: Additional potential sites for lion re-introduction

1. Madhav National Park:

Area: 354.61 km²

State: Madhya Pradesh

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B ³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: Madhav National park is situated between 77° 15' to 78° 30' E and 24° 50' to 25° 55' N in the district of Shivpuri, Madhya Pradesh. The area of the National Park is 354.61 km² surrounded by the Vindhya range of mountains with an altitudinal difference of 360-490m from mean sea level ³⁵. The park is connected to Kuno-Palpur Sanctuary and serves as an important wildlife corridor in the landscape. The area falls under the semi-arid bio-geographic zone, Gujarat-Rajputana biotic province 4B ³⁴ and Kathiarbar-Gir Dry Deciduous Forests eco-region ³⁷. Terrain is undulating and characterized by gentle slopes, small rocky hills multiple nallahs and contains artificial lake inside the National Park (<https://natureconservation.in/>). The dry deciduous vegetation of the park is mostly dominated by *Anogeissus pendula*, *Lannea coromandelica*, *Grewia tilifolia*, *Boswellia serrata*, *Sterculia eurens* and *Acacia catechu*. The park also comprises flat grasslands around the reservoirs³⁸.

Prey-predator diversity: The major carnivore species includes Wolves (*Canis lupus*), Leopards (*Panthera pardus*), Sloth Bear (*Melursus ursinus*), Striped hyaenas (*Hyena hyena*), Golden jackal (*Canis aureus*), Indian fox (*Vulpes bengalensis*) and Wild Dog (Dhole) (*Cuon alpinus*). Among herbivores Sambar (*Rusa unicolor*), Spotted deer (*Axis axis*), Barking deer (*Muntiacus vaginalis*), Indian Gazelle (*Gazella bennettii*), Nilgai (*Boselaphus tragocamelus*) and Wild pig (*Sus scrofa*) are common ^{35, 39}.

Climate: The landscape experiences a sub-tropical climatic condition with extremely hot summer and relatively moderate winter. Winter ranges from November to February, summer ranges from March to June and rainy season starts from mid-June and continues up to September. The average annual temperature varies between 4°C in winter and 45°C in summer. The average annual rainfall in the landscape ranges between 1000 mm to 1250 mm ³⁸.

Anthropogenic pressure: About 130 villages surrounding with 10 km radius from the National Park and only one village is situated within. There is high pressure of both timber and non-timber forest product collection by the villagers ³⁵.

Priority and immediate management interventions needed:

The landscape of Madhav National park which have good connectivity with Kuno National Park creates an area of more than 3000 km² with good forest and less biotic pressure compared to other protected forests proposed herewith for lion re-introduction. There is ample space for lions to disperse from Kuno or vice-versa. Therefore, this landscape is on top of the priority list. However, to make it conducive for lion conservation some immediate management inventions need to be implemented, such as, resettlement of remaining villages from the protected area, habitat improvement, eradication of weeds, infrastructure development to reduce human-large carnivore conflict such as power-fencing and livestock vaccination to prevent disease spread from domestic animals.

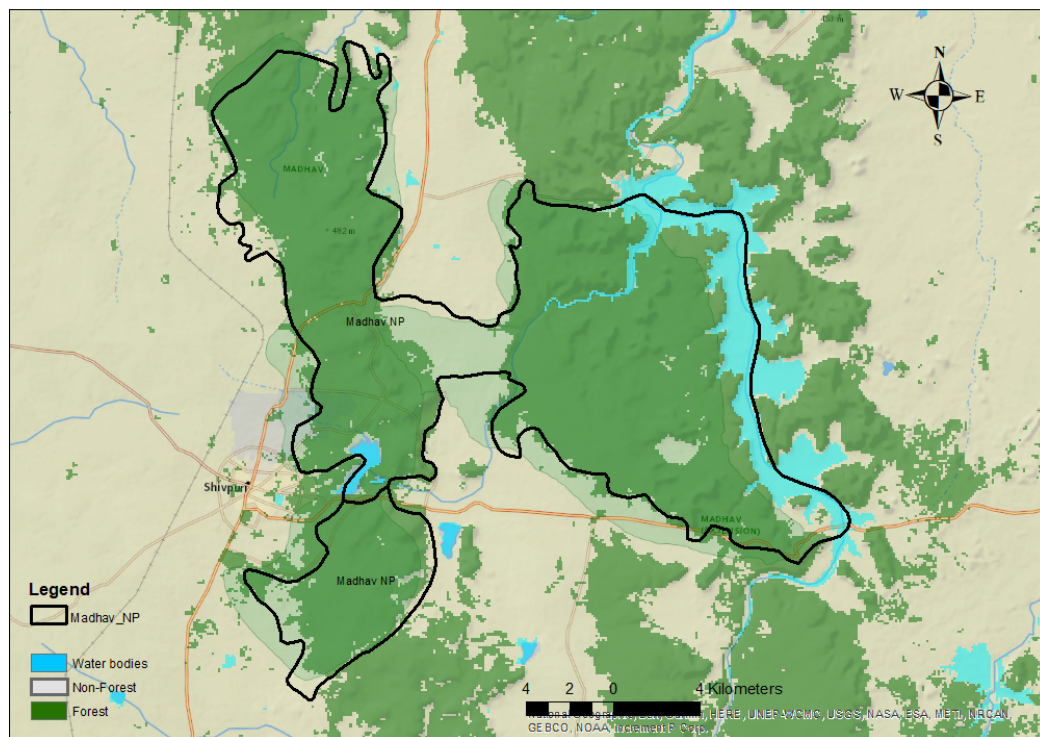


Figure 1: Madhav National Park, Madhya Pradesh

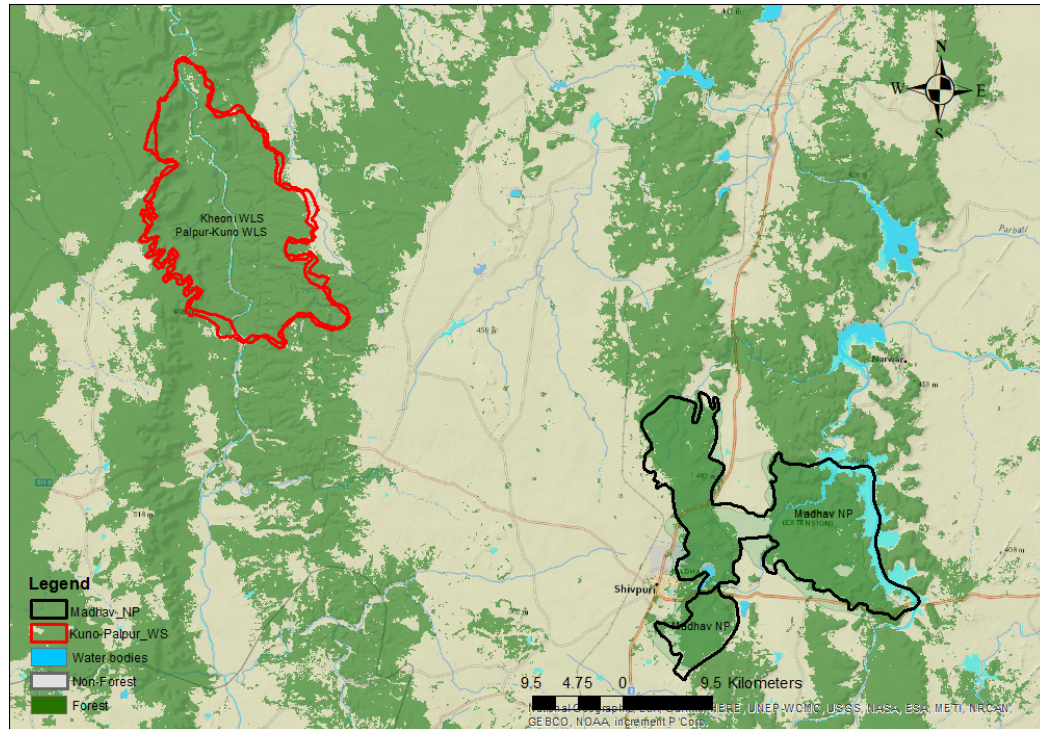


Figure 2: Madhav National Park and Kuno-Palpur Wildlife Sanctuary complex, Madhya Pradesh

2. Sitamata Wildlife Sanctuary:

Area: 422.95 km²

State: Rajasthan, India

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B ³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: Sitamata Wildlife Sanctuary is situated between 24° 04'-24° 23' N and 74° 25'-74° 40' E in the south-western part of Rajasthan State. It is spanning over an area of 422.95 km² in the districts of Pratapgarh and Chittaurgarh ⁴⁰. It falls under the “semi-arid bio-geographic zone; Gujarat-Rajputana biotic province 4B ³⁴ and Kathiarbar-Gir Dry Deciduous Forests eco-region ³⁷. The strategic location of the sanctuary at the junction of the Aravalli, Vindyan hill ranges, and Malwa Plateau creates a unique ecosystem for many fauna and flora. The landscape is characterized by gentle slopes, rugged and hilly terrains interspersed with network of river and streams, wetlands, natural deep gorges and fine grooves of mixed woodlands. The altitude ranges from 280m to 600m above mean sea level.

Prey-predator diversity: The sanctuary forms the north-western most limit of Teak-bamboo mixed forest and distribution limits of many animal species ⁴¹. The sanctuary is known to support a great diversity of mammalian fauna including many carnivorous species such as Wolves (*Canis lupus*), Leopards (*Panthera pardus*), Striped hyaenas (*Hyena hyena*), Golden jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Indian fox (*Vulpes bengalensis*), Honey badger (*Melivora capensis*), Small Indian civet (*Viverricula indica*), Common palm civet (*Paradoxurus hermaphroditus*) and Grey mongoose (*Herpestes edwardsi*) and Ruddy mongoose (*Herpestes smithii*). Among herbivores Hanuman langur (*Semnopithecus entellus*), Sambar (*Rusa unicolor*), Spotted Deer (*Axis axis*), Nilgai (*Boselaphus tragocamelus*), Four horned antelope (*Teracerus quadricornis*) and Wild pig (*Sus scrofa*) ⁴⁰. Besides the sanctuary is rich with many other rare and endangered faunas such as Indian pangolin (*Manis crassicaudata*), Indian hedgehog (*Hemiechinus micropus*) and Indian Giant Flying Squirrel (*Petaurista ptilipensis*) etc.

Climate: The landscape experiences a sub-tropical climatic condition characterized by distinct winter, summer and monsoon season. Winter ranges from November to January, summer ranges from March to May and rainy season starts from mid-June and continues up to September. The average annual temperature varies between 6°C in winter and 45°C in summer and the average annual rainfall is about 756 mm with maximum up to 951 mm and minimum 517mm.

Anthropogenic pressure: There are about 193 villages and 14 Gram Panchayats inside the forest, mostly comprising of people from Meena and Bhil community. Of which about 8 Gram Panchayats comprising of 96 villages are within the core area. There are problems of encroachment, heavy grazing by domestic livestock, illicit cutting of wood, timber and bamboo along with other agricultural activities, ⁴¹, heavy infestation of weeds, poor prey base, lack of antipoaching strategies, many linear infrastructures cutting across the tiger reserve and poorly trained frontier forest staff, etc. ⁴².

Priority and management interventions needed:

The landscape of Sitamata Wildlife Sanctuary and adjoining forest patches with similar biotic and abiotic factors makes it a suitable for reintroduction of lions. However, at present the protected area experiences high anthropogenic pressure as mentioned above. About 11000 households are known to present within the sanctuary ⁴³. Therefore, to make the landscape conducive for lions we need to reduce anthropogenic pressure and create inviolate space by resettling villages from the park, create alternate livelihood opportunity for people, improve habitat quality, weed eradication, vaccination of livestock in the peripheral villages to stop disease spread to wild animals and infrastructure development for anti-poaching activities and to reduce human wildlife conflict.

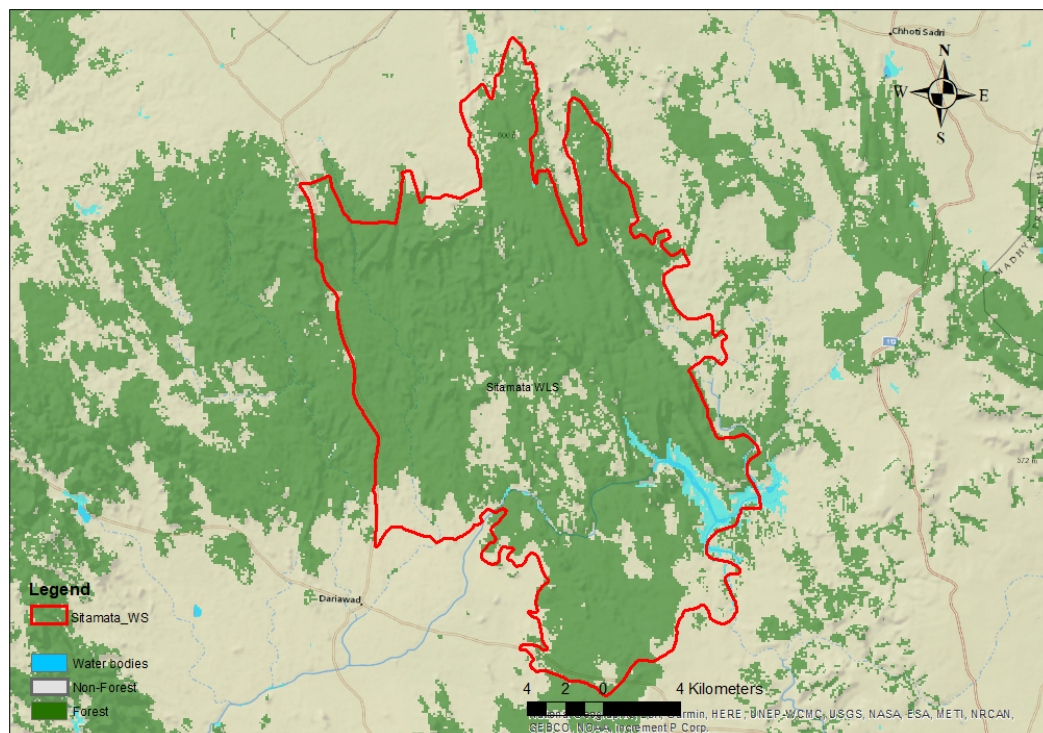


Figure 3: Sitamata Wildlife Sanctuary, Rajasthan

3. Mukundara Hills Tiger Reserve:

Area: 759.99 km²

State: Rajasthan, India

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B ³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: Mukundara hills tiger reserve lies between 24° 38' to 25° 7' N and 75° 26' to 76° 11' E across four districts of Rajasthan namely Kota, Bundi, Chittorgarh and Jhalawar. It covers an area of about 759.99 km² of which 417.17 km² is designated as core and 342.82 km² is designated as buffer ⁴⁴. Located in the eastern bank of river Chambal, the tiger reserve consists of three wildlife sanctuaries, Darrah National Park, Chambal Wildlife Sanctuary and Jaswant Sagar Wildlife Sanctuary. The tiger reserve has connectivity with Ranthambore tiger reserve, Ramgadh Vishdhari and Bhainsarogar wildlife sanctuary. Further, it is also connected to the Gandhi Sagar wildlife sanctuary in Madhya Pradesh ²³. The area falls under the semi-arid bio-geographic zone, Gujarat-Rajputana biotic province 4B ³⁴ and Kathiarbar-Gir Dry Deciduous Forests eco-region ³⁷. The vegetation type is characterized by dry deciduous forest ⁴⁵ dominated by *Anogeissus pendula*, *A. latifolia*, *Acacia catechu*, *Ziziphus mauritiana*, *Flacouritia indica*, and *Acacia leucifloea*.

Prey-predator diversity: Although there are no tigers in the reserve, it harbors a great variety of carnivorous and herbivorous species. Carnivore species includes Wolves (*Canis lupus*), Leopards (*Panthera pardus*), Sloth Bear (*Melursus ursinus*), Striped hyaenas (*Hyena hyena*), Golden jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Desert cat (*Felis margarita*), Indian fox (*Vulpes bengalensis*), Honey badger (*Melivora capensis*), Small Indian civet (*Viverricula indica*), Common palm civet (*Paradoxurus hermaphroditus*), Grey mongoose (*Herpestes edwardsi*) and Small Indian mongoose (*Herpestes javanicus*). Among herbivores Hanuman langur (*Semnopithecus entellus*), Rhesus macaque (*Macaca mulatta*), Sambar (*Rusa unicolor*), Spotted deer (*Axis axis*), Indian Gazell (*Gazella bennettii*) Nilgai (*Boselaphus tragocamelus*), Indian crested porcupine (*Hystrix indica*) and Wild pig (*Sus scrofa*) ²³.

Climate: The landscape experiences a sub-tropical climatic condition with extremely hot summer and relatively moderate winter. Winter ranges from November to February, summer ranges from March to June and rainy season starts from mid-June and continues up to September. The average annual temperature varies between 6°C in winter and 45°C in summer and the average annual rainfall is about 795 mm ranges from 600 mm to 990 mm ⁴⁶.

Anthropogenic pressure: There are about 12 villages inside the park, dominant community is “Gurjars” whose principle occupation is livestock rearing and dependent on the forest for fuelwood and fodder ⁴⁴. The landscape experiences many threats due to deforestation, over-grazing, encroachment of forest land, exploitation of forests resources and uncontrolled quarrying ⁴⁷.

Priority and management interventions needed:

The complex of Mukundara Hills Tiger reserve and Gandhi Sagar Wildlife Sanctuary along with other adjoining forest creates an area of about 2000 km² which have great potential to develop it for lion conservation. At present, there are many villages inside the Mukundara Hills tiger reserve and have great anthropogenic impact on the ecosystem. Therefore, resettlement of villages from the park is of utmost necessity to create inviolate spaces for the lions to thrive. Further, to reduce the dependency of the villagers on the forest, it is important to create alternative livelihood opportunities. Intensive management interventions for habitat improvement, weed removal and anti-poaching activities are required. Strict law enforcement against illegal activities such as quarrying within the eco-sensitive zone of the PA need to be prohibited. Roughly there are more than 10,000 households within or in close proximity to the park ⁴³.

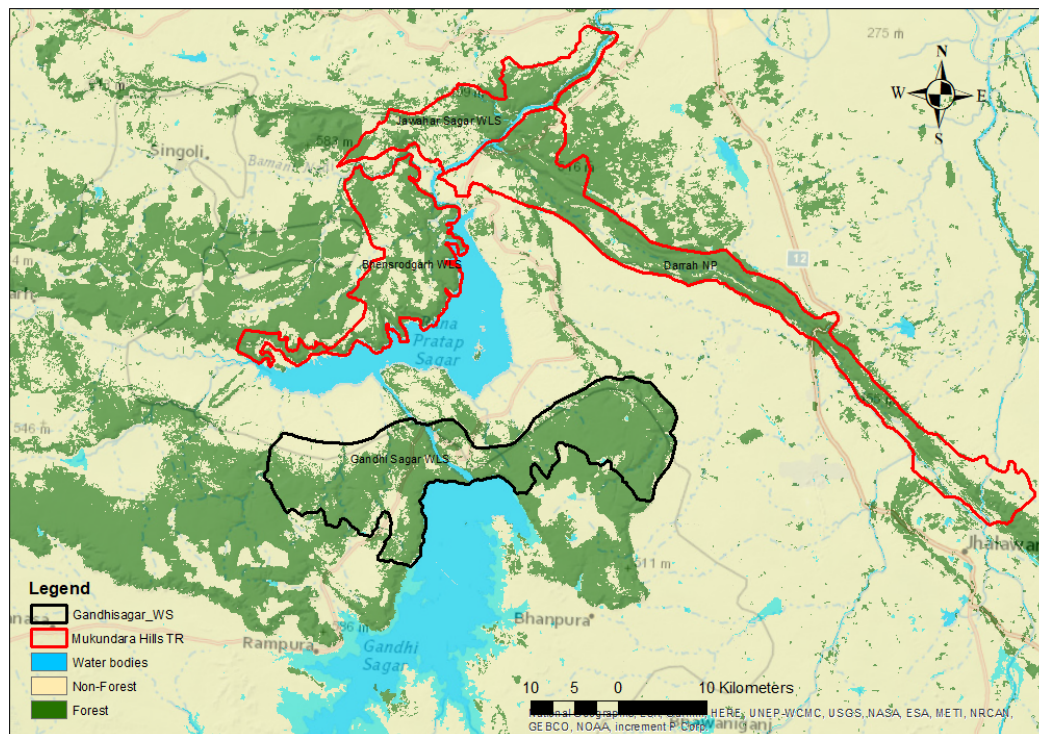


Figure 4: Mukundara Hills Tiger Reserve of Rajasthan and Gandhi Sagar Wildlife Sanctuary of Madhya Pradesh complex

4. Gandhi Sagar Wildlife Sanctuary:

Area: 368.62 km²

State: Madhya Pradesh, India

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: Gandhi Sagar Wildlife Sanctuary is situated between 23° 45'-25° 2' N and 74° 42'-75° 50' E in the Malwa plateau of Madhya Pradesh. Spreading over an area of 368.62 km² the sanctuary is divided into two parts by the Chambal river running through it. The western part of the sanctuary falls in the district of Nimach while the eastern part is in Mandsaur district. The sanctuary is connected to Mukundara Hills Tiger Reserve of Rajasthan. The forests of the sanctuary can be broadly classified into (i) Northern tropical dry mixed deciduous forests [5B/C2]; (ii) Dry Deciduous Scrub Forests [5/DS1] and (iii) *Anogeissus pendula* forests [5/E1]⁴⁵. The Gandhisagar dam is one of the largest inland reservoirs in the country with a submergence area of 650 km², and there are good flat grasslands available around the submergence⁴⁸.

Prey-predator diversity: Not much information available on the mammalian diversity of Gandhisagar Wildlife Sanctuary. However, there are reports in popular media about common sightings of Leopards (*Panthera pardus*), Striped hyenas (*Hyena hyena*) and Golden jackal (*Canis aureus*). Besides, the park also harbors Wolves (*Canis lupus*), and this sanctuary is known to be one of the strongholds of Indian Wild Dog (Dhole) (*Cuon alpinus*). The most commonly sighted wild herbivores include Hanuman langur (*Semnopithecus entellus*), Sambar (*Rusa unicolor*), Indian Gazell (*Gazella bennettii*) and Nilgai (*Boselaphus tragocamelus*)⁴⁹.

Climate: The landscape experiences a sub-tropical climatic condition with extremely hot summer and relatively moderate winter. Winter ranges from November to February, summer ranges from March to June and rainy season starts from mid-June and continues up to September. The average annual temperature varies between 10°C in winter and 43°C in summer and the average annual rainfall is about 795 mm ranges from 600 mm to 990 mm⁴⁸.

Anthropogenic pressure: There are many religious tourism sites inside the wildlife sanctuary. Some of the famous attractions are Chaurasigarh, Chaturbhujnath temple, Bhadkaji rock paintings, Narsinghjar, Hinglajgarh Fort and Taxakeshwar temple⁵⁰.

Priority and management interventions needed:

With good connectivity to Mukundara Hills Tiger Reserve in Rajasthan this landscape along with other adjoining forest patches creates an area of about 2000 km² of continuous forests and holds great potential for reintroduction of lion. There are about 530 households are known to be present within the sanctuary. Therefore, to reduce biotic pressure, religious tourisms needs to be regulated, mining or other development activities withing the eco-sensitive zone and along the habitat corridors need to be prevented. Habitat improvement, weed eradication, water management, grasslands management need to carryout. Vaccination of livestock around the park is important to prevent disease transmission to wild animals. Alternative livelihood opportunity creation is necessary to reduce dependency of villagers on forest product.



Figure 5: Gandhi Sagar Wildlife Sanctuary of Madhya Pradesh

5. Kumbhalgarh Wildlife Sanctuary:

Area: 610 km²

State: Rajasthan, India

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: Kumbhalgarh Wildlife Sanctuary is situated between 73°15' E, 25°00' N to 73°45' E, 25°30' N in the Rajsamand District of central-southern Rajasthan State and spanning over an area of 610 km² out of which 224.890 km² is designated as core zone and 385.638 km² area as buffer. It falls under the “semi-arid bio-geographic zone; Gujarat-Rajputana biotic province 4B³⁴ and Kathiarbar-Gir Dry Deciduous Forests eco-region³⁷. The sanctuary forms the ecotone between the hilly forests of Aravallis and the Thar desert⁵¹. The vegetation is characterized by tropical dry deciduous forests with a mix of savanna grasslands, patchy riparian corridors of dense perennial canopy. The geography of the Sanctuary is characterized by highly eroded remnant of Precambrian uplift which follows the Aravali hill and covers the hill ranges of Kumbhalgarh, Sadri, Desuri and the Bokhada. The elevation varies from 275m to 1155 m from mean sea level⁵². Kumbhalgarh hills forms the catchment of many rivers and nallahs⁵¹.

Prey-predator diversity: The sanctuary is diverse in terms of carnivorous species and their prey. Carnivore species includes Wolves (*Canis lupus*), Leopards (*Panthera pardus*), Sloth Bear (*Melursus ursinus*), Striped hyaenas (*Hyena hyena*), Golden jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Indian fox (*Vulpes bengalensis*), Small Indian civet (*Viverricula indica*), Common palm civet (*Paradoxurus hermaphroditus*), Grey mongoose (*Herpestes edwardsi*) and Small Indian mongoose (*Herpestes javanicus*). Among herbivores Hanuman langur (*Semnopithecus entellus*), Sambar (*Rusa unicolor*), Indian Gazell (*Gazella bennettii*) Nilgai (*Boselaphus tragocamelus*), Four horned antelope (*Teracerus quadricornis*), Indian crested porcupine (*Hystrix indica*) and Wild pig (*Sus scrofa*)⁵¹.

Climate: The landscape experiences a sub-tropical climatic condition with extremely hot summer and relatively moderate winter. Winter ranges from November to February, summer ranges from March to June and rainy season starts from mid-June and continues up to September⁵¹. The average annual temperature varies between 5°C in winter and 48°C in summer and the average annual rainfall is about 725 mm ranges from 403 mm to 950 mm⁵².

Anthropogenic pressure: There is no human settlement inside the sanctuary ⁵¹. However, about 94,388 people are known to live within 5 km of the boundary of the sanctuary in about 33 settlements. The sanctuary experiences threats from over grazing by domestic livestock, illegal tree cutting, forest fire and invasive plants like *Lantana camara* and *Prosopis juliflora* ⁵².

Priority and management interventions needed:

Although there are no human settlements within the protected area, biotic pressure from the peripheral villages are immense. Therefore, creating alternative livelihood opportunities for the villages around the sanctuary is necessary to reduce dependency of people on forest products. Habitat improvement to increase prey base density, weed eradication, water management, vaccination of livestock around the sanctuary boundary to prevent disease transmission to wild animals, and infrastructure development for anti-poaching activities and mitigate human-wildlife conflict needs to be carried out.

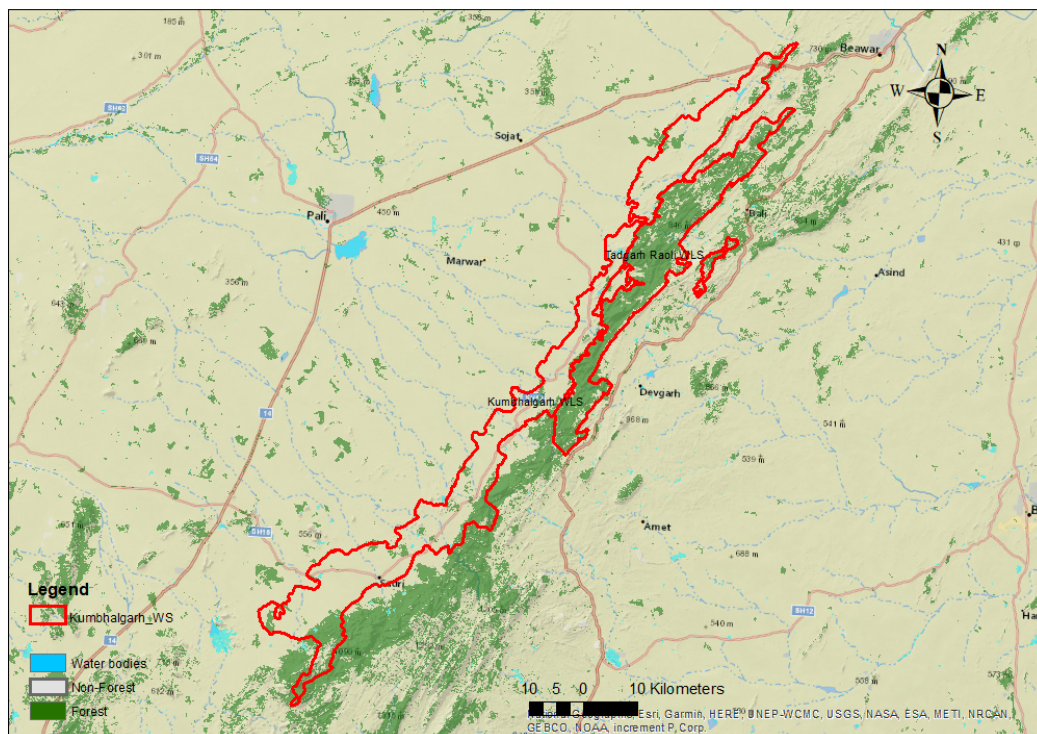


Figure 6: Kumbhalgarh Wildlife Sanctuary, Rajasthan

6. Jessore-Balaram Ambaji WLS and adjoining landscape:

Area: 542.08 km² (Balaram Ambaji WLS)

180 km² (Jessore Wildlife Sanctuary)

State: Gujarat, India

Biogeographic zone: Semi-arid biogeographic zone, Gujarat-Rajputana biotic province 4B ³⁴

Vegetation Type: Tropical dry deciduous forest

Geography: The areas of Jessore-Balaram Ambaji WLS comprises of Jessore Sloth Bear Sanctuary, Balaram-Ambaji WLS and adjoining forests in the north western part of Gujarat state. Both the sanctuaries are in the Aravali hill range and connected to the Mount Abu in Rajasthan through degraded forest corridors. The landscape is spanning between 23° 35' to 24° 43' N and 71° 0' to 73° 0' E in the district of Banaskantha, Gujarat. The total area of the Jessore Wildlife Sanctuary is 180 km² whereas the area of Balaram Ambaji Wildlife Sanctuary is 542.08 km². The straight aerial distance between the protected areas are not more than 7 km and forms a complex of forested landscape which harbors many important flora and fauna. The landscape falls under the semi-arid bio-geographic zone, Gujarat-Rajputana biotic province 4B ³⁴ and Kathiarbar-Gir Dry Deciduous Forests eco-region³⁷. The terrain is characterized by rugged hills cutting through by few rivers and rivulets. The landscape has great ecological significance as it acts as a buffer between the desert eco-system and the dry deciduous type of forest ecosystem ⁵³. Elevation ranges from 10m to 1000m (Jessore peak) above mean sea level. The vegetation is characterized by dry deciduous forests with dominant trees of *Commiphora wightii*, *Bombaxceiba*, *Cassia auriculate*, *Cassia fistula*, *Diospyros melanoxylon*, *Ziziphus mauritiana* and *Butea monosperma*.

Prey-predator diversity: The landscape provides space for a great diversity of mammalian species. The major carnivorous species found in the landscape are Sloth Bear (*Melursus ursinus*), Indian leopards (*Panthera pardus*), Wolves (*Canis lupus*), Striped hyaenas (*Hyena hyena*), Golden jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Indian fox (*Vulpes bengalensis*), Honey badger (*Melivora capensis*), Small Indian civet (*Viverricula indica*), Common palm civet (*Paradoxurus hermaphroditus*) and Grey mongoose (*Herpestes edwardsi*) and Ruddy mongoose (*Herpestes smithii*). Among herbivores Hanuman langur (*Semnopithecus entellus*), Rhesus macaque (*Macaca mulatta*) Sambar (*Rusa unicolor*), Spotted Deer (*Axis*

axix), Nilgai (*Boselaphus tragocamelus*), and Wild pig (*Sus scrofa*). Besides the sanctuary is rich with many other rare and endangered faunas such as Indian pangolin (*Manis crassicaudata*), Indian hedgehog (*Hemiechinus micropus*) and Indian Giant Flying Squirrel (*Petaurista ptilipensis*) etc. ⁵⁴.

Climate: The landscape experiences a sub-tropical climatic condition with extremely hot summer and relatively moderate winter. Winter ranges from November to February, summer ranges from March to June and rainy season starts from mid-June and continues up to September. The average annual temperature varies between 5°C in winter and 46°C in summer. The average annual rainfall in the landscape 765mm⁵⁵.

Anthropogenic pressure: There are many temples in the landscape, besides the famous Balaram and Ambaji temples, which attracts millions of tourists. Average 5-6 lakh pilgrims are known to visit these temples every week. The landscape also experiences intensive mining for marbles, around the sanctuaries⁵⁶.

Priority and management interventions needed:

This landscape with restoration of habitat corridors between the two protected areas forms a good area for re-introduction of lions within Gujarat. Unlike Barda this landscape does not have connectivity with the existing lion population in Gir, that ensures the isolation of the re-introduced population of the species. There are about 15523 households known to be present within the sanctuary⁴³. Therefore, this landscape needs intensive management interventions to resettle villages from the protected areas, improve habitat quality, prey base, regulate mining activities within the eco-sensitive zone, vaccination of livestock in the peripheral villages and conflict mitigation strategies.

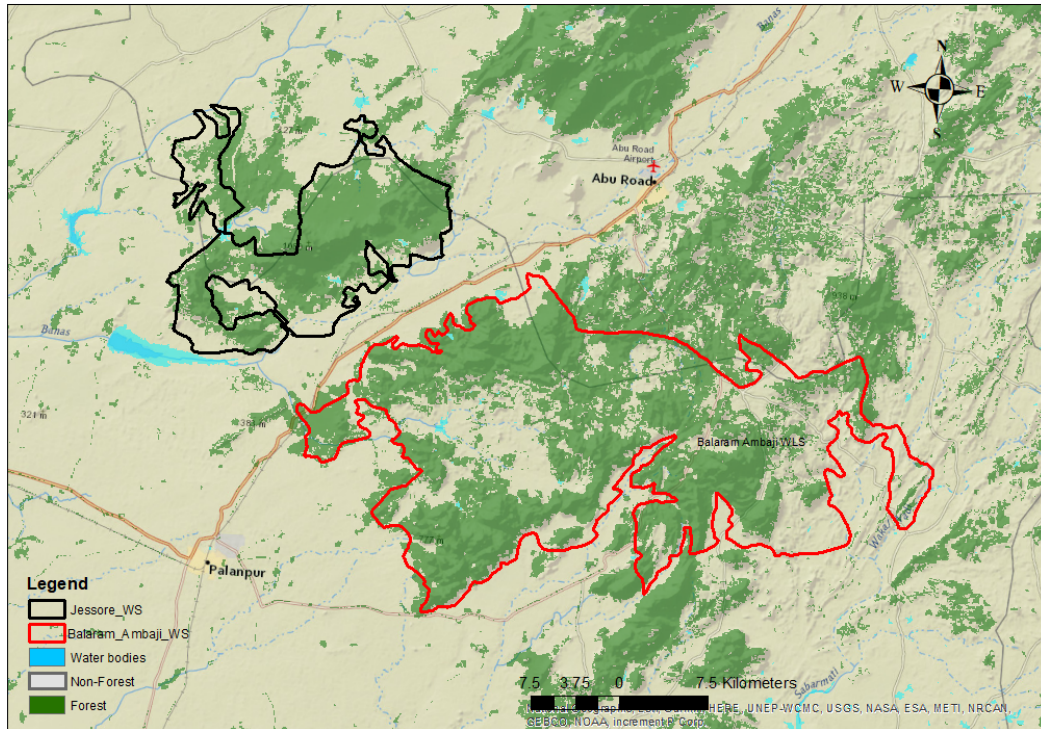


Figure 7: Jessor-Balaram Ambaji Wildlife Sanctuary complex, Gujarat

Appendix 3: Comparison between Gir Protected Area and Kuno National Park

In order to minimize the extinction probability of Gir lions from any probable future stochastic event like a disease epidemic or a natural calamity, the Kuno Protected Area in Madhya Pradesh was identified 1995 as a potential site for establishing a second lion population. Substantial investments by the Government of India and Madhya Pradesh have been made to make Kuno ideal for receiving lions. Comparisons of the following parameters between Gir and Kuno explicate Kuno as being ready for receiving and nurturing a second population of Asiatic Lions in India:

Parameter	Gir Protected Area	Kuno Protected Area
Size of the Protected Area & human free area	The total area of the Gir is 1,883 km ² inclusive of a Gir Wildlife Sanctuary of 1,153 km ² . The only area exclusively for Asiatic lions in the world is the Gir National Park of about 259 km ² .	Total area of Kuno Wildlife Division is 1,235 km ² . Human free Kuno National Park is about 748 km ² . About 2.7 times larger than Gir National Park.
Bio-geographic zone	Semi-arid zone (4b), Gujarat-Rajputana biogeographic region ³⁴	Semi-arid zone (4b), Gujarat-Rajputana biogeographic region. The topography of Kuno is better suited for lions.
Habitat and vegetation	Dry deciduous teak forests in the western part of Gir PA and dry deciduous thorn forests, scrub forests and dry savannah forests in the eastern part of the PA.	Northern tropical dry deciduous forest. Under this type Southern tropical dry deciduous forest, <i>Anogeissus pendula</i> forest and scrub and <i>Boswellia</i> forest, <i>Butea</i> forest, dry savannah forest and grassland are predominant.
Size of the forested landscape outside the PA where lions can potentially disperse and persist. Historical distribution.	Currently lions occupy about 13,000 km ² of Saurashtra landscape adjoining the Gir PA. This area is shared with intense agriculture, high density livestock and people. Forested areas & grasslands (Vidis) that are actual refuges for lions in this landscape are < 500 km ² .	About 4,000 km ² of contiguous forest patch surrounds Kuno PA. This area has low human and livestock density compared to the Saurashtra Landscape. It was occupied by lions in medieval times. Descriptions of lion hunts in this region are found in Mughal writings. The entire landscape is conducive for lions.

Prey densities in Protected Area	Wild prey (#/km²) Chital – 56.1 (8.3), Sambar – 2.4 (0.5), Nilgai – 0.3 (0.1), Wild pig – 3 (1.3), Chinkara – 0.6 (0.3), Chowsingha – 0.2 (0.1), Langur – 9.1 (2.2), Peafowl – 10 (2). Domestic prey Cattle – 4.4 (4), Buffalo – 9.4 (3.4) [numbers within parentheses are Standard Errors]	Wild prey (#/km²) Chital – 52.5 (8), Sambar – 6.6 (1), Nilgai – 3.5 (1), Wild pig – 4.3 (0.9), Chinkara – 0.6 (0.3), Chowsingha – 0.8 (0.3), Langur – 12.5 (3) Domestic prey Feral Cattle – 1.4 (0.7) [numbers within parentheses are Standard Errors] In 2006 chital densities were as low as 5 per sq. km ⁵⁷ but with good protection by 2014 they increased to > 50 per sq. km ⁵⁸.
Investments made and impact on local livelihood	Communities in the Gir Landscape making direct or indirect profit from lions were more tolerant toward them. The two important economic benefits from lions were: (a) their propensity to predate nilgai and wild pigs, both considered as agricultural pests and (b) presence of lions offered an opportunity for tourism and employment.	Government of India and Madhya Pradesh Government have already spent approximately USD 3.4 million till 2007 for relocating 24 human settlements from Kuno WLS and for other habitat management interventions ⁵⁹. The local economy around Kuno is poor and would benefit from jobs and economies created by lion reintroduction.

Furthermore, Madhya Pradesh Forest Department has an excellent track record of conserving and managing large carnivores such as tigers within the state since long. As per the recent all India tiger estimation report released by the Honorable Prime Minister, Madhya Pradesh bags the reputation of having the largest number of tigers and is the “tiger state” of the country with a population of 526 tigers. The state supports ~14% of tiger and ~23% of India's leopard population and has 15,156 km² of forests occupied by tigers ³⁶. Some of the Protected Areas in Madhya Pradesh like Bandhavgarh, Kanha Tiger Reserves have tiger population with more than 80 individuals, which serve as major source populations ensuring the persistence of other tiger metapopulations across the whole Central Indian Landscape ²³. Moreover, the state forest department also has the expertise and capacity of capturing, handling, translocating and radio-telemetry which all will be essential for managing the reintroduced lion population in Kuno.

References

1. Tabasum, W., Ara, S., Rai, N., Thangaraj, K. & Gaur, A. Complete mitochondrial genome sequence of asiatic lion (*Panthera leo persica*). *Mitochondrial DNA Part B Resour.* **1**, 619–620 (2016).
2. Mitra, S. *et al.* De novo assembly and annotation of Asiatic lion (*Panthera leo persica*) genome. *bioRxiv* 549790 (2019). doi:10.1101/549790
3. Manuel, M. de *et al.* The evolutionary history of extinct and living lions. *PNAS USA* **117**, 10927–10934 (2020).
4. Armstrong, E. E. *et al.* Long live the king: chromosome-level assembly of the lion (*Panthera leo*) using linked-read, Hi-C, and long-read data. *BMC Biol.* (2020). doi:10.1186/s12915-019-0734-5
5. Figueiró, H. V. *et al.* Genome-wide signatures of complex introgression and adaptive evolution in the big cats. *Sci. Adv.* **3**, 20 (2017).
6. O'Brien, S. J., Roelke, M. E. & Marker, L. Genetic basis for species vulnerability in the cheetah. *Science* (80-.). **227**, 1428–1434 (1985).
7. Keller, L. F., Arcese, P., Smith, J. N. M., Hochachka, W. M. & Stearns, S. C. Selection against inbred song sparrows during a natural population bottleneck. *Nature* **372**, 356–357 (1994).
8. Hedrick, P.W. & Garcia-Dorado, A. Understanding inbreeding depression, purging, and genetic rescue. *Trends. Ecol. Evol.* **31**, 940-952 (2016).
9. O'Brien, S.J. *Prides and prejudice, 35-55: In Tears of the cheetah and other tales from the genetic frontier: the genetic secrets of our animal ancestors.* O'Brien, S.J. Thomas Dunne Books, NY, USA. (2003).
10. Banerjee, K. *Ranging patterns, habitat use and food habits of the satellite lion populations (Panthera leo persica) in Gujarat, India* (Dissertation/Ph.D. thesis). India: Forest Research Institute Deemed University, Dehradun, India, pp 435. (2012).
11. Banerjee, K., Jhala, Y.V. & Pathak, B.J. Demographic structure and abundance of Asiatic lions (*Panthera leo persica*) in Girnar Wildlife Sanctuary, Gujarat, India. *Oryx* **44**, 248–251 (2010).
12. Ashraf, N. V. K., Chellam, R., Molur, S., Sharma, D. & Walker, S. *Population & Habitat Viability Assessment P.H.V.A. and Global Animal Survival Plan Workshops 18-21 October 1993, Baroda, India.* (1995).
13. Banerjee, K., Jhala, Y. V., Chauhan, K. S. & Dave, C. V. Living with Lions: The Economics of Coexistence in the Gir Forests, India. *PLoS One* **8**, 1–11 (2013).
14. Mungi, N. A., Qureshi, Q. & Jhala, Y. V. Expanding niche and degrading forests: Key to the successful global invasion of *Lantana camara* (sensu lato). *Glob. Ecol. Conserv.* **23**, e01080 (2020).
15. Dave, C. & Jhala, Y. Is competition with livestock detrimental for native wild ungulates? A case study of chital (*Axis axis*) in Gir Forest, India. *J. Trop. Ecol.* **27**, 239–247 (2011).
16. Jhala, Y.V., Banerjee, K., Basu, P., Chakrabarti, S. & Gayen, S. *Assessment of Barda landscape for reintroduction of Asiatic lions.* Technical Report, Wildlife Institute of India, Dehra Dun, India, pp xiii + 146. TR-2014/003. (2014).
17. Kitchener, A. C. *et al.* A revised taxonomy of the Felidae. The final report of the Cat Classification Task Force of the IUCN/ SSC Cat Specialist Group. *Cat News Special Issue* 11–80 (2017). Available at: https://repository.si.edu/bitstream/handle/10088/32616/A_revised_Felidae_Taxonomy_CatNews.pdf?sequence=1&isAllowed=y. (Accessed: 9th September 2020)
18. Ochoa, A., Onorato, D. P., Fitak, R. R., Roelke-Parker, M. E. & Culver, M. De Novo Assembly and Annotation from Parental and F1 Puma Genomes of the Florida Panther Genetic Restoration Program. (2019). doi:10.1534/g3.119.400629

19. Saremi, N. F. *et al.* Puma genomes from North and South America provide insights into the genomic consequences of inbreeding. *Nat. Commun.* **10**, (2019).
20. Pennycuik, C. J. & Rudnai, J. A method of identifying individual lions with an analysis of the reliability of identification. *J. Zool. London* **160**, 497–508 (1970).
21. Jhala, Y. V., Qureshi, Q., Bhuvra, V., & Sharma, L. N. Population estimation of Asiatic lions. *J. Bombay Nat. Hist. Soc.* **96**, 3–15 (1999).
22. Gogoi, K., Kumar, U., Banerjee, K. & Jhala, Y.V. Spatially explicit density and its determinants for Asiatic lions in the Gir forests. *PLoS ONE* **15(2)**, e0228374. (2020).
23. Jhala, Y.V., Qureshi, Q. & Nayak, A.K. (eds.). *Status of tigers, copredators and prey in India, 2018*. National Tiger Conservation Authority, Government of India, New Delhi, and Wildlife Institute of India, Dehradun. ISBN No. 81-85496-50-1. (2020).
24. Jhala, Y. V., Qureshi, Q., and De, P. (2005). *Lion: a Software to Identify Individual Lion and Database Management*, Wildlife Institute of India. Available online at: http://wii.gov.in/lion_id (accessed September 11, 2020).
25. Gujarat Forest Department. *Report on Poonam Avlokan (Full Moon Observations) of Asiatic Lions in the Asiatic Lion Landscape: June, 2020*. Wildlife Division, Sasan-Gir. (2020).
26. Pocock, R.I. Lions of Asia. *J. Bombay Nat. Hist. Soc.* **34**, 638-665. (1930).
27. Wildt, D.E. *et al.* Reproductive and genetic consequences of founding isolated lion populations. *Nature* **329**, 328-331. (1987).
28. O'Brien, S.J., Wildt, D.E. & Bush, M. The African cheetah in genetic peril. *Sci. Am.* **254**, 84-92. (1986).
29. Packer, C. *et al.* Case study of a population bottleneck: lions of the Ngorongoro Crater. *Con. Biol.* **5**, 219 – 230. (1991).
30. Gilpin, M.E. & Soulé, M.E. *Minimum viable populations: processes of species extinction*, 19-34: In *Conservation Biology: the science of scarcity and diversity*, Soulé, M.E. (ed.), Sinauer, Sunderland, MA. (1986).
31. Roelke-Parker, M. E. *et al.* A canine distemper virus epidemic in Serengeti lions. *Nature* **379**, 411-445. (1996).
32. Chellam R., Joshua, J., Williams, C.A. & Johnsingh, A.J.T. *Survey of potential sites for reintroduction of Asiatic lions*. Unpublished Report, Wildlife Institute of India, Dehradun, 39 pp. (1995).
33. Banerjee, K. & Jhala, Y.V. Demographic parameters of endangered Asiatic lions (*Panthera leo persica*) in Gir forests, India. *J. Mammal.* **93**, 1420 – 1430.
34. Rodgers, W.A. & Panwar, H.S. *Planning a wildlife Protected Area network in India. Volume I*. Wildlife Institute of India, Dehra Dun, 339 pp. (1988).
35. Beazley, N. K. *Enclosing the pristine myth: the case of Madhav National Park, India*. Available at https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/592/Beazley_Kim.pdf?sequence=1 (2006).
36. Jhala, Y.V. *et al.* *Status and Distribution of Major Mammalian Fauna in the State of Madhya Pradesh*. (Wildlife Institute of India, Dehradun. TR 2016/013, Pp 102, 2016).
37. WWF. Southern Asia: Northwestern India | Ecoregions | WWF. *World Wildlife Fund (WWF)* (2020). Available at: <https://www.worldwildlife.org/ecoregions/im0206>. (Accessed: 4th September 2020)
38. Chauhan, S. S., Tiwari, A., Sheikh, A. & Sharma, S. Study on biological spectrum of Madhav National Park, Shivpuri Madhya Pradesh India. *J. Bio. Env. Sci.* **2014**, 258–262 (2014).
39. <https://mpforest.gov.in/>. *Madhav National Park, Shivpuri*.

40. Bhatnagar, C., Koli, V. K. & Sharma, S. K. Sunbasking behaviour of elliot's giant flying squirrel *petaurista philippensis* (elliot) in sitamata wildlife sanctuary, Rajasthan, India. *J. Bom. Nat. Hist. Soc.* **109**, 196–197 (2012).
41. (FES), F. for E. S. Assessment of Biodiversity in Sitamata Wildlife Sanctuary : A Conservation Perspective Foundation for Ecological Security. *Found. Ecol. Secur. P.B. No. 29, Jahangirpura, P.O. Gopalpura, Vadod* 388 370, (2010).
42. Kumar, S. What went wrong with the tiger reintroduction programme at Mukudara Hills Tiger Reserve in Rajasthan? – Newsroom24x7. (2020). Available at: <https://newsroom24x7.com/2020/09/01/what-went-wrong-with-the-tiger-reintroduction-programme-at-mukudara-hills-tiger-reserve-in-rajasthan/>. (Accessed: 9th September 2020)
43. NASA Open Data, P. India Village-Level Geospatial Socio-Economic Data Set: 1991, 2001 | NASA Open Data Portal. (2001). Available at: <https://data.nasa.gov/dataset/India-Village-Level-Geospatial-Socio-Economic-Data/4ri6-783z>. (Accessed: 8th September 2020)
44. Sen, M. K. & Nama, K. S. Documentation of Ophiofauna of Mukundara Hills National Park , Kota , Rajasthan (India). **1**, 21–24 (2013).
45. Champion, H. & Seth, S. *A revised study of the forest types of India*. (Government of India Press, 1968).
46. Kumar, D., Chauhan, P. S., Bhatnagar, P. & Nagar, B. Phytodiversity Characterization of Mukundara Hills Tiger Reserve An overview on Inherent Potential of Underutilized Fruits View project PG teaching View project. *Artic. Int. J. Curr. Microbiol. Appl. Sci.* (2020). doi:10.20546/ijcmas.2020.907.235
47. Singh, P. & Reddy, G.V. *Lost Tigers Plundered Forests: A report tracing the decline of the tiger across the state of Rajasthan (1900 to present)*. WWF-India, New Delhi. (2016).
48. Tiwari, A. P., Khanna, K. K. & Dubey, P. C. Angiospermic diversity of Gandhi Sagar Wildlife Sanctuary , Madhya Pradesh , India. *Geophytology* **45**, 139–151 (2015).
49. Gandhi Sagar Wildlife Sanctuary | Wildlife in India Foundation. Available at: <https://wildlifeinindia.in/gandhi-sagar-wildlife-sanctuary/>. (Accessed: 9th September 2020)
50. Gandhi Sagar Wildlife Sanctuary - WildTrails Recent Sightings | The One-Stop Destination for all your Wildlife Travels. Available at: <https://wildtrails.in/gandhi-sagar-wildlife-sanctuary/>. (Accessed: 9th September 2020)
51. Bohra, P. *Faunal Exploration of Kumbhalgarh Wildlife Sanctuary Rajasthan Zoological Survey of India Kolkata. Conservation Area Series* (2013).
52. Chhangani, A. K. Avifauna of Kumbhalgarh Wildlife Sanctuary, in the Aravalli hills of Rajasthan. *Zoos' Print Journal* **17**, (2002).
53. Basu, P. *Assessment of landscape pattern for modelling habitat suitability for lions and prey species in Gir Protected Area, Gujarat*. PhD Thesis, FRI Deemed University, Dehradun, India (2013).
54. Balaram Ambaji Wildlife Sanctuary | Wildlife Sanctuaries | Available at: <https://forests.gujarat.gov.in/balaram-sanctuary.htm>. (Accessed: 9th September 2020)
55. Mewada, T. P., Tiwari, U. L. & Kotia, A. Fruiting species influence the seasonal use of the habitat by sloth bear in and around Balaram Ambaji Wildlife Sanctuary, Gujarat, India. *Not. Sci. Biol.* **11**, 183–190 (2019).
56. Rithe, K. & Madhusudan, M. *Site inspection report on proposal for rationalisation of boundaries of Balaram-Ambaji Wildlife Sanctuary (BAWS), Gujarat Submitted to the Standing Committee of the National Board for Wildlife A view of Balaram Ambaji Wildlife Sanctuary*. (2013).
57. Banerjee, K. *Estimating the ungulate abundance and developing the habitat specific effective strip width models in Kuno Wildlife Sanctuary, Madhya Pradesh*. M.Sc Theis, Forest Research Institute University, Dehradun, 170 pp. (2005).

58. Bipin, C.M., Patil, N.A., Prabhu, C.L., Sharma, U., Sharma, V.S., Mishra, R.K. & Jhala Y.V. *Status of predators and prey in Kuno Wildlife Sanctuary, Madhya Pradesh*. Wildlife Institute of India, Dehradun and Madhya Pradesh Forest Department. (2015).
59. Johnsingh, A.J.T., Goyal, S.P. & Qureshi, Q. Preparations for the reintroduction of Asiatic lion *Panthera leo persica* into Kuno Wildlife Sanctuary, Madhya Pradesh, India. *Oryx* **41**, 93 - 96. (2007).